LUBRICATION

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Counteracting the Effects of Water by Selective Lubrication

WATER conditions present one of the most aggravating problems with which the lubricating engineer is confronted today. Oftentimes through lack of appreciation of the probable detriments, the problem is made all the more severe by the very people he is trying to help—the plant personnel. In part their sins are those of omission through too careful consideration of first costs; in part, due to the fact that they do not realize the amount of water which may develop through condensation.

The study which has been given to means and methods of sealing has resulted in condensation becoming the primary source of moisture in many types of modern lubricating systems. The possibility of direct leakage of water or condensed steam is becoming more and more remote through the good offices of the designing engineer. Machinery builders, too, are more generous today in considering the cost of adequate sealing media for bearings, gear and chain enclosures and other working elements which might otherwise be subjected to water or steam conditions.

It is a different matter to eliminate condensation of moisture from the air. Usually it is costly, and only attainable by the use of hermetically sealed housings. Where breathing is essential, obviously this latter becomes impossible, so one is restricted to the normal types of gaskets, spring seals or metallic packing available for such service. None can be entirely air-tight, although they may very well be water-tight.

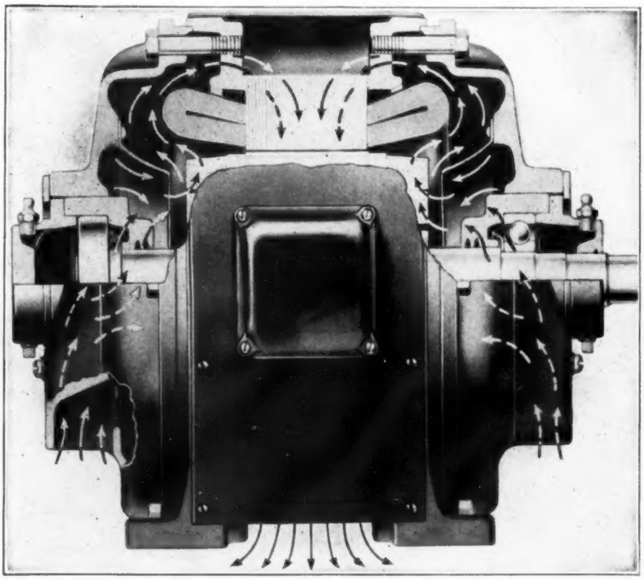
So it is with the water vapor content of the air with which we must be concerned in the lubrication of parts where condensation may become cumulative.

This water vapor content is not a constant. It is controlled by the relative humidity. Since this latter denotes the degree of saturation at a given temperature it can become a measure of the amount of water we can expect to obtain by cooling a measured volume of the air in question to a temperature below its dew point. When air has all the water vapor it can hold it is said to be fully saturated. So when we speak of air having sixty percent relative humidity it means that it contains sixty percent of the amount it would be capable of holding at the temperature in question.

Temperature is a most important item in the condensation of water vapor from the air. Where it is maintained comparatively uniform condensation will be virtually unobservable. Let this range become relatively wide, however, as for example where a reduction gear unit may be operated intermittently, and free water will begin to show itself in a comparatively short time.

The higher the relative humidity or degree of saturation, the more water can we expect, especially if temperatures go periodically from one extreme to the other. When air contains all the moisture it can hold at any tempera-

ture, this latter is termed the Dew Point temperature. Obviously, where it is relatively high, but a slight amount of cooling will be necessary to develop quite an appreciable volume of water, especially where the air is circulating through or around the point of accumulation.



Courtesy of General Electric Company

Fig. 1—Showing the ventilating system of a G.E. splash proof induction motor. This is so designed to provide adequate cooling and yet prevent entry of liquids or non-lubricating foreign matter.

This comparatively elementary discussion of one of the phenomena of Physics is of much concern to the lubricating engineer. It is in reality the basis upon which he must work in the selection of the most suitable lubricant for any set of operating conditions where moisture is the predominating objection.

So much for the possibility of water becoming present in mechanisms which would be better off were it absent. Now to consider those operations where working parts must function more or less continuously in the presence of water, and therefore, be lubricated accordingly. The extent to which it may be necessary to maintain lubrication in the presence of water is becoming more and more evident as machinery such as the air tool, for example, is adapted to new usages. As a result, there has been extensive research on the part of the petroleum industry in an effort to develop lubricants of moisture-resisting characteristics, or lubricants which will emulsify to a sufficient extent to develop and maintain a positive lubricating film between the wearing surfaces involved.

Perhaps the earliest effort to counteract the washing effect of water was the development of compounded steam cylinder oils for the lubrication of steam cylinders where wet steam was employed. Wherever moisture may be involved in steam, the washing action of the former will tend to rapidly impair any film of lubricant which may be present upon the cylinder walls, valves and valve seats. It was proved, however, that by adding in the neighborhood of four to ten percent of animal oil, such as tallow or degras, that sufficient adhesiveness would be brought about to create a decidedly tenacious and moisture-resisting lubricating film.

This idea has since been studied in the development of the highest grade of distillate lubricating oils for marine Diesel engine air compressor service, where condensation during standby may oftentimes lead to rusting and corrosion of the cylinder surfaces. Fatty oil, in this case, has been used as the compounding and emulsifying medium in the lubricating oil.

The hydraulic accumulator, the deep well pump and the multitude of materials handling equipment operating out-of-doors, have all developed other phases of operation wherein it is absolutely essential to counteract the effects of water upon the lubricants used, as well as the wearing surfaces.

Selection of Lubricants to Meet These Conditions

Where there is provision for oil lubrication on machinery subjected to water conditions, the oil must be studied from the viewpoint of its adhesive characteristics, its viscosity and its pour test.

In oils for such service, the emulsifying constituent is normally an animal oil, although in marine service it is customary to use rapeseed oil to develop this same characteristic in marine engine oils.

Animal and vegetable oils are commonly called fixed oils. They are incapable of distillation, adhesive to metal and have the inherent ability of emulsifying with water to form a decidedly tenacious lubricating film. This latter will be comparatively permanent, whereas an emulsion which may be developed by a mineral oil alone, when agitated with water, will be more or less temporary, depending upon the degree of refinement of the oil.

It is inadvisable, however, to depend upon the emulsifying characteristics of a mineral oil alone, hence, the custom of adding a few per-

cent of fixed oil to render emulsification more positive. The amount of such compound will, of course, depend upon the service involved. Where an oil is to be used for worm gear or Diesel engine air compressor lubrication, approximately 3 percent of fatty oil will suffice. For steam cylinder service, in turn, the percent of compound may range from 4 to 12 percent, or even higher. As a general rule, lard oil or degras (wool oil) are used in such products. Usually, the amount and nature of the compound and the original viscosity of the mineral oil will depend upon the service to be ultimately performed.

Relation to Viscosity

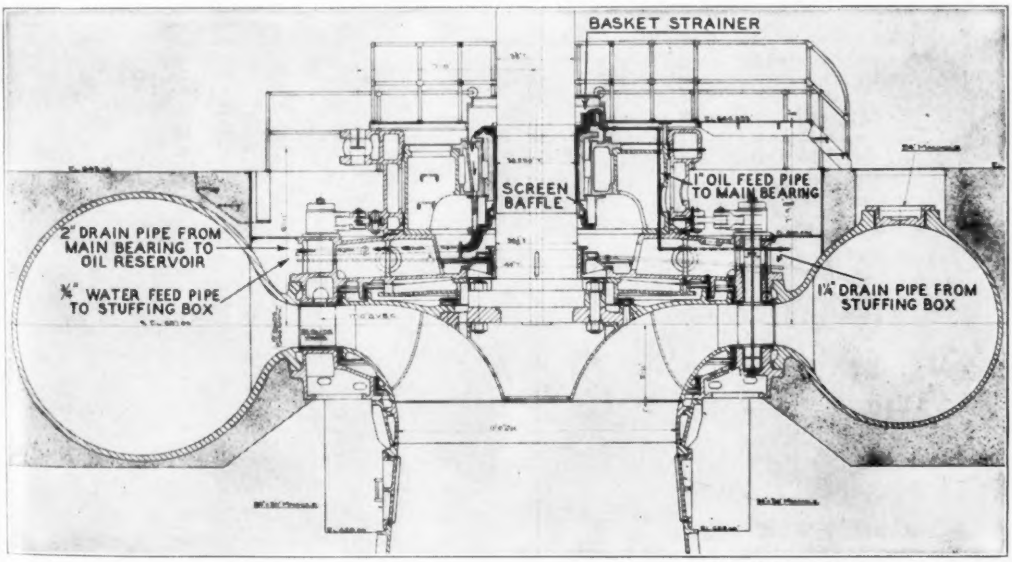
It is interesting to note that the viscosity must also be considered in service of this type. Viscosity, however, will be a function of the operating temperature. In marine engine service, for example, where reciprocating engine bearings operate at comparatively normal temperatures, a viscosity of approximately 600 to 700 seconds Saybolt at 100 degrees Fahr., will suffice. Steam cylinder oils, on the other hand, will require a considerably higher viscosity ranging, as a rule, from 100 to 180 seconds Saybolt at 210 degrees Fahr. In turn, a gear compound for use under water conditions should range in the neighborhood of 1000 to 2000 seconds Saybolt at 210 degrees Fahr. Here, however, it is a matter of the pressure which must be counteracted rather than temperature, although in steel mill service hot water will frequently be encountered.

The Pour Test

Testing for fluidity at low temperatures originated with the "cold test", which was regarded as that temperature at which an oil loses its fluidity, or the temperature at which solid matter commences to separate. Later the term "pour test", was applied, as oils from a wider source of supply came into usage.

There has been confusion at times in regard to methods of determining this temperature, and ignorance in regard to the factors which may have influence upon accurate determination. Especially is this true in connection with the preparation of the sample for test. The effect of cold upon lubricating oils is not the same as upon simple fluids such as water, alcohol, glycerin, benzine, etc. The latter have fixed and accurately ascertainable freezing points at which a complete change from the liquid to the solid state takes place, but lubricating oils which are mixtures of hydrocarbons of various melting points or freezing points behave like solutions, and frequently deposit some portion of their constituents before the whole mixture solidifies.

Interesting phenomena which can only be explained by changes in the inner or molecular structures are observed when chilling many lubricating oils. If, for example, we take the pour test of an oil without previous heating and then take the pour test of the same oil after heating to 120 degrees Fahr., after allowing it to cool to the same temperature as the first, the oil which is heated solidifies at a considerably higher temperature and the in-

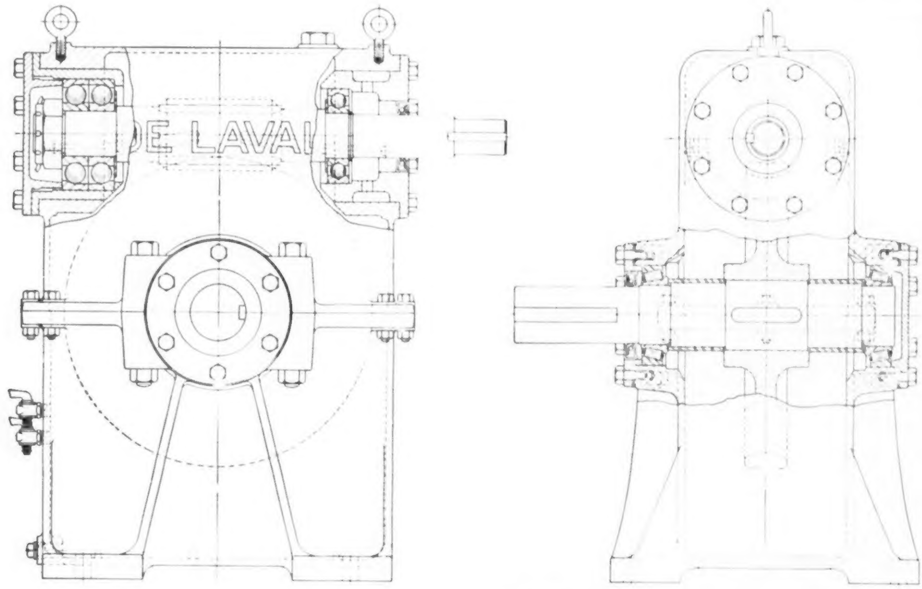


Courtesy of Allis-Chalmers Mfg. Co.

Fig. 2—Assembly cross-section of one of the four 115,000 H.P. hydraulic turbines for Boulder Dam. Note oil feeds, drains and other provisions to protect lubrication.

fluence from preheating seems to be effective for a considerable time, at least for twenty-four hours. Heating to temperatures below 90 degrees Fahr., apparently has no influence.

Another factor which has an effect on the test is stirring the oil while cooling to determine the pour test. In case an oil is stirred it solidifies at a lower temperature than when held stationary. This may be explained on the assumption that the movement of the oil destroys the formation of a fine network of microscopic particles of wax which are separating out.



Courtesy of De Laval Steam Turbine Co.

Fig. 3—Details of a De Laval worm gear as adapted to marine service. Note bearing seals to prevent breathing and abnormal condensation.

This segregation gives the oil a certain support and thereby facilitates solidification. In an analogous way this explanation may apply to the influence of preheating; the waxy or asphaltic particles are probably transformed by warming, into a very strongly dispersed state from which it is possible to form a finer and thicker network than in the oil which has not been heated.

Numerous tests have been devised to determine the pour test of lubricating oils, each of which gives various and sundry results in the hands of different operators, due not only to ambiguity and lack of conciseness of the description of apparatus and method, but also in the application of the methods to various types of oils. Committee D-2 of the American Society for Testing Materials have taken considerable pains to work out a standard method for this determination. This method, while not new in principle, is more complete in detail than any previously published.

Grease Lubrication

A grease in turn requires consideration of the soap content. This latter must be comparatively non-soluble at average temperatures; in other words, it must be of a lime or calcium base. Were a soda soap used, due to the fact that this is normally soluble in water, upon contact with this latter, the soap would be dissolved from the oil, rendering this latter incapable of maintaining effective lubrication, especially if there is any possibility of it being washed out from between the bearing elements.

It is also important to remember that wherever water conditions may prevail there will be the possibility of comparatively low temperatures developing, especially on materials handling equipment in the coal mine, stone quarry or where pneumatic tools are involved. As a result, the oil content of any grease to be used for such service should have as low a pour test as possible.

OPERATING CONDITIONS

More complete understanding of the practical difficulties which may be encountered in lubricating certain types of machinery in the presence of water can be gained by study of the conditions under which such equipment must operate. Features of design are also a

factor. The conclusions will hold irrespective of the source of the water.

Marine Reduction Gears

Worm reduction gears in certain types of marine service or elsewhere under conditions of relatively high humidity may be seriously affected by condensation wherever subjected to a comparatively wide temperature range. Builders of such equipment are normally of the opinion that a highly refined mineral oil, of viscosity commensurate with the operating conditions, compounded with a small amount of specially prepared fatty oil, is necessary to meet the pressure conditions. A further advantage pertinent to such a lubricant is its ability to emulsify with any water which may have condensed in the case.

In some fields of marine service, however, involving turbo-driven units of considerably high speed, it has been attempted to lubricate with a straight mineral oil. In certain instances this has been found to lead to rusting and corrosion of both the worm gears and ball bearing elements, caused undoubtedly by abnormal condensation. The above conditions have been, furthermore, all the more noticeable where such mechanisms are only run at intervals and therefore fluctuate over a comparatively wide temperature range. Where located in such a position as to be exposed to direct draft from the ventilators, the possibility of condensation becoming extreme could well be expected. Obviously the above would present an operating condition which should be given special attention from a lubricating point of view, with serious consideration of a suitably compounded oil regardless of prevailing specification or any desire to reduce the number of grades of lubricants used in the plant.

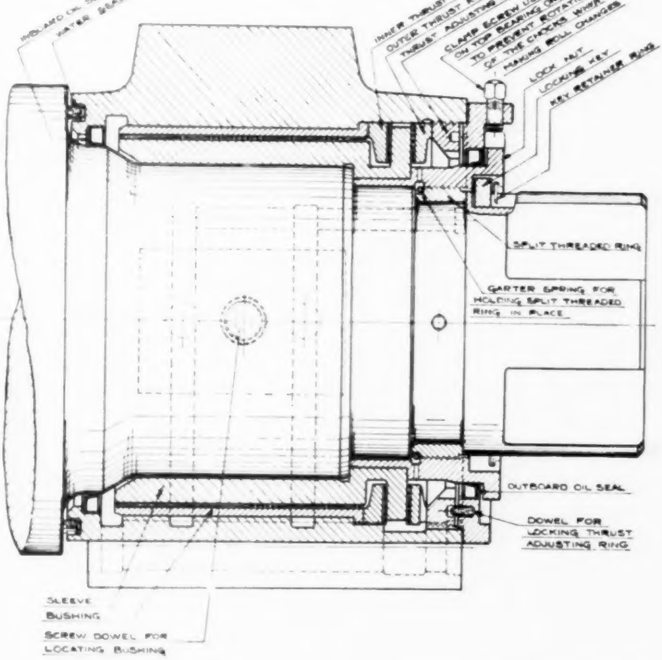
Rock Drills

Water conditions in the operation of rock drills will frequently impose a decided load upon the lubricants involved. Such equipment often operates at a considerable distance below ground, consequently water may become a serious factor, even if the tools are designed for operating on dry air, for condensation may develop to a marked extent especially when the tools are not operating. There is also the possibility that a considerable amount of water may surround the exterior part of the tools and air piping due to mine leakage. In addition, water may be intentionally mixed with the air to be used in some tools of this type to serve the purpose of washing cuttings from the drill hole.

In the wet type of tool, such as the hammer drill, water leakage must also be guarded against, otherwise operation may be affected. As a result, conditions in the cylinders of such tools are somewhat similar to those encountered in the cylinders of water pumps. It is important to remember in the case of mine tools, that this water may also frequently contain an appreciable percentage of acid which would increase the possibility of subsequent corrosion.

All this has required the use of compounded lubricants wherever equipment such as hammer drills may be operating in the presence of water. Such lubricants, of course, function on the same principle as do steam cylinder oils. In other words, they emulsify with water by virtue of their fatty content, creating an adhesive emulsion which adequately resists the washing effects of water and sticks tenaciously to all wearing elements.

Compounded lubricants, however, are only recommended for air tools wherein water is intentionally mixed with the air or where it is more or less positively known that a certain amount of water may gain entry into the tool mechanisms during operation.



Courtesy of Morgan Construction Co.

Fig. 1—Cross section of the tapered neck Morgoil bearing, as designed for steel mill service. This is an oil lubricated bearing equipped with water seals to protect lubrication.

When rock drills are designed to function dry, they should be absolutely dry,—that is, free from moisture as far as possible, for the usual lubrication recommendations for such equipment will specify straight mineral products. These, if properly refined and of the requisite viscosity, and pour test, will adequately withstand any slight washing effect that may develop due to condensation of moisture from the compressed air as normally used. They will not, however, protect the wearing surfaces against any excessive wear, as may occur if the tool is dropped in the mud or allowed to remain exposed to the elements for any length of time when not in use.

The ultimate result will, of course, be rusting and corrosion, with subsequent difficulty in operation, an inability on the part of the tool to perform its rated amount of work and a necessity for repair or replacement of parts.

Selection of Steam Cylinder Oils

The composition of a cylinder oil should be considered with respect to the amount of moisture in the steam. Saturated steam will always contain a certain percentage of moisture. Superheating to a sufficient degree, however, will counteract any line and cylinder condensation which may be caused by the cooling effect of the piping or cylinder walls, and the expenditure of heat by the expansion stroke. Unless the degree of superheat is quite high, the latter part of the exhaust will often be wet.

It is this presence of moisture which will usually result in a film of straight mineral lubricating oil being rapidly washed off from the cylinder walls and valve seat surfaces when in contact with the steam. To secure proper lubrication under wet steam conditions it is necessary therefore to either increase the rate of flow of a straight mineral oil or else substitute an oil which contains a certain percentage of fatty compound, such as degras or tallow. This latter procedure is the most practicable and economical.

When To Use Straight Mineral Oils

The practice of using a straight mineral oil to lubricate wet steam is customary only where the presence of a fatty oil in the exhaust steam is objectionable. The increased amount necessary to insure proper lubrication will often result in imperfect atomization. As a consequence, oil accumulations in the cylinder will be prevalent and carbon deposits developed.

This will hold true especially in multiple expansion engines equipped with receivers and re-heaters, the high temperatures to which the oil is subject being very conducive to carbonization. In poppet valve engines carbon formation of this nature may often cause imperfect operation of the valves.

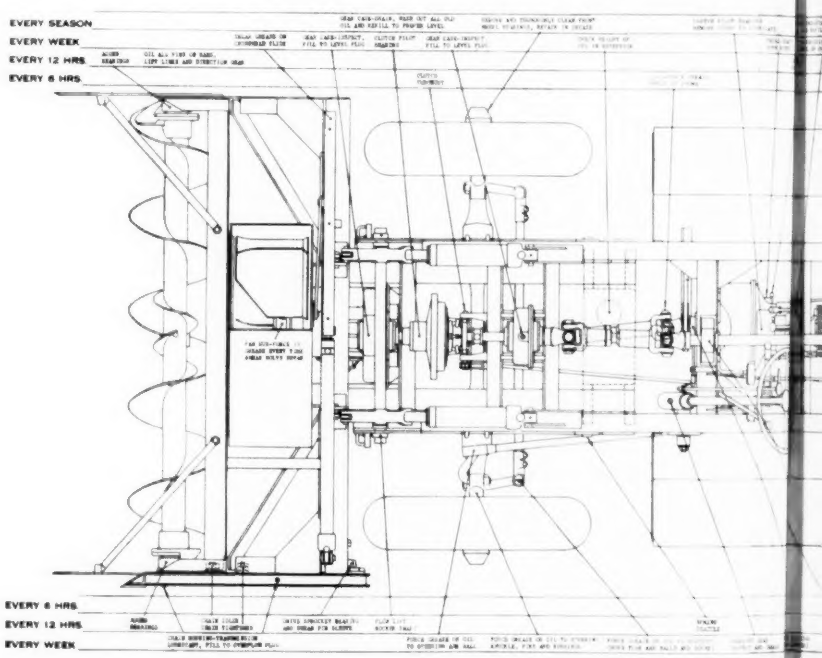


Fig. 5—Lubrication chart for the Snogo snow removal machine showing essential work... with most prevalent, a fact which requires careful designing to prevent entry of water and im... of h...

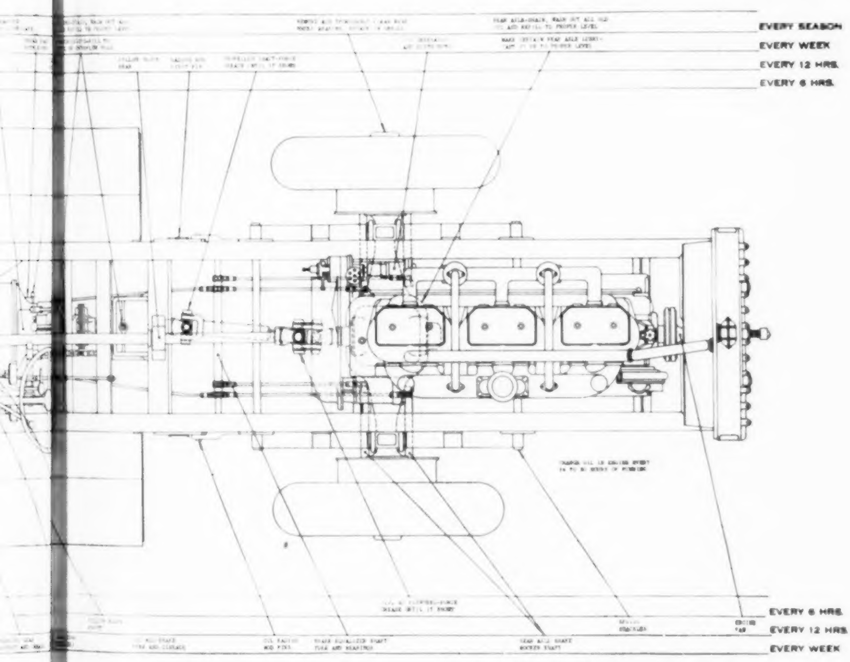
Compounding to Meet Water Conditions

Where a compounded oil is used adhesiveness is developed towards the metal, repelling the moisture in the steam from the cylinder wall. The lubricating film thus has a greater affinity for the cylinder walls and other wearing surfaces and becomes highly resistant to the washing action of the water in the steam. Naturally the greater the percentage of moisture in the steam the higher should be the fatty compound content of the lubricant.

In general the amount of compound should not exceed 10 percent, however, except in extreme cases of abnormally wet steam. We must remember that an excessive amount of fatty compound, beyond that necessary to

form the requisite emulsion will not improve the lubricating value of the oil. In fact, it may even be an objection, especially under continued exposure to high temperatures on account of the tendency that animal fats have of decomposing under such conditions.

As a result the amount of compound to use in an oil should be just sufficient to maintain a film of oil on the cylinder walls. This is especially true where the exhaust steam is to be used for feed water heating or in process work of any nature. Under such conditions it is more important than ever to observe caution in selecting and using steam cylinder lubricants. Present day practice is to more and more reduce the quantity of compound and to improve its quality.



Courtesy of Klauer Manufacturing Co.

...ial work... with frequency of lubrication. In snow removal service exposure to moisture conditions is ... and im... of lubrication.

That tendency in compounded oils which causes them to emulsify with water to develop adhesiveness also prevents ready separation from water in condensed steam; furthermore, the more completely atomized the oil the more difficulty will it have in separating from water.

Oil in the form of fine emulsions in a boiler combines with the boiler compounds to cause foaming, or with the boiler impurities to produce a coating over the tubes and fire surfaces. This coating seems to form more readily over relatively clean tubes than over dirty ones.

A very thin layer of oily sludge over a tube surface will so insulate it that there is not only a large loss in heat efficiency, but the rise in temperature of the metal may be so excessive as to cause burning out or explosion of the boiler.

Conveyor and Materials Handling Equipment

Anti-friction bearings and wire rope require primary consideration in the lubrication of belt conveyors and hoisting mechanisms in mine, quarry or excavating operations. Belt conveyor idlers are normally better protected, since their bearings are housed and provided with means for pressure grease lubrication. The possibility of contamination and subsequent damage through corrosion, is, therefore, remote. The designers have made adequate provision to prevent entry of water, by use of suitable seals.

Wire Rope Requirements

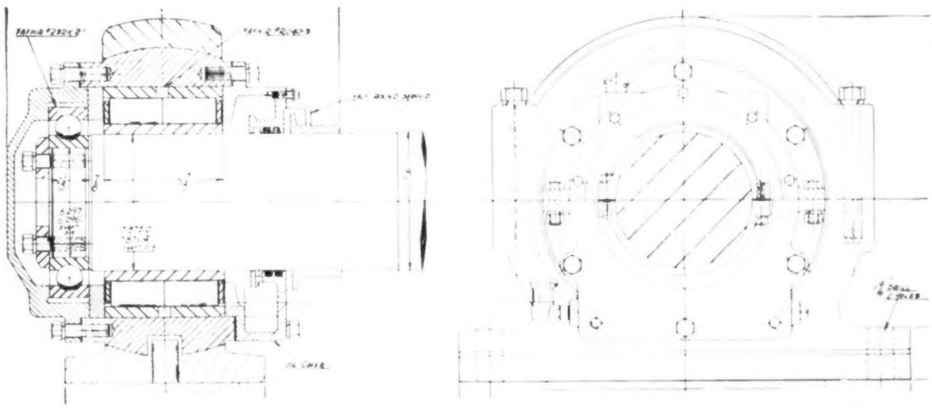
Lubrication of wire rope, however, is one of the most important factors in any plant where materials in bulk such as ore, coke or coal are to be handled; for the ultimate efficiency of operation is, to a large extent, dependent upon the condition of the cables or wire ropes.

Wherever a rope may have one or two broken strands due to rusting or wear traceable to improper lubrication, this may not only cause a tie-up of the entire machine if such strands interfere with the operation of sheaves, or other companion cables, but may also present a distinct hazard. Any wire rope in such condition is just that much weaker and less capable of handling the existing loads.

It is not enough to assume that because such ropes come from the manufacturers in a lubricated state, being in general wound on an oil saturated core, that further lubrication is unnecessary. Under exposed operation there is constant friction and wear between the strands and a tendency to squeeze out any contained lubricant, especially when the ropes pass over sheaves or around drums. The renewal of this product is, therefore, an absolute necessity.

The matter of friction between the strands of a wire rope is essentially the same as friction between a bearing and a shaft. Overheating

and abnormal wear will practically always result, to reduce the load carrying capacity and increase the amount of power consumed in operation. This only can be overcome by effective lubrication, brought about by the proper application of a suitably prepared wire rope lubricant, which will be capable of penetrating to the innermost strands and core of the rope, and sufficiently adhesive and viscous to resist being prematurely squeezed out or washed off by rain or sleet.



Courtesy of The Fafnir Bearing Co.

Fig. 6—The load characteristics of a paper pulp grinder call for the use of heavy duty roller bearings; furthermore, the unit must be self-aligning and designed to exclude moisture. This is brought about by special sealing and means for oil circulation.

Lubricant Characteristics

A good wire rope lubricant, in addition to possessing the properties mentioned above, must not tend to cake, gum or ball up, especially if contaminated with an excess of dust, dirt or metallic particles. Furthermore, it must be resistant to the thinning-down effects of higher temperature. This, of course, directly involves the viscosity or relative fluidity of the product. In fact, viscosity of such products is the essential characteristic in purchasing. It should not, however, be assumed as being the chief guide as to the actual suitability. The ability to function, penetrate and stick under actual operating conditions, is of more vital importance. A wire rope lubricant, therefore, should not be purchased haphazardly, nor on a price basis alone. The potential difficulties that might result in cold weather are too serious. To meet the aforesaid requirements it should, in general be a straight mineral petroleum product containing no filler or thickening medium. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which cannot be depended upon.

It is for this reason that greases or soap thickened mineral oils are relatively unsuited to wire rope lubrication. To attain the requisite body a comparatively high percentage of soap would be necessary. Soap, of course, serves as the carrying medium for the oil. It has relatively no lubricating value, however; so this property in the resultant product is decreased to a marked extent. Furthermore, the adhesive characteristic of greases is low. In consequence, such products will not, in general meet the requirements of wire rope lubrication.

Application of Wire Rope Lubricants

As a general rule wire rope lubricants are so viscous or heavy as to require heating before application. To merely attempt to daub or paint a rope with such a product at normal temperatures would be relatively impossible. Even though the surface might be more or less coated, the possibility of penetration occurring to any extent would be remote. This latter is the secret of effective wire rope lubrication. The amount of wear occurring between the exterior of such a rope and the sheaves is not as marked as that which occurs between adjacent strands when the rope is flexed or bent as in passing over sheaves or hoisting drums. On the other hand, bending promotes penetration of the lubricant.

A very satisfactory method of treating wire ropes is to use a form of split box through which the rope can be run. Such a box can be readily built in the average plant, with suitable provision for rendering it sufficiently tight to prevent the lubricant from leaking out, even when reduced in viscosity by heating. The slow passage of the rope through such a bath of heated compound will insure that not only will the surface be coated, but also that the requisite penetration takes place on the inner strands. Further slow working of the rope over the

sheaves before the lubricant has time to cool completely will tend to aid in bringing about the maximum of penetration.

Steel Mill Service

One of the most aggravating conditions requiring lubrication in the presence of water is involved in steel plant service where hot water or steam will frequently prevail in the blooming mill as well as on certain other rolling machinery. In such operations it is often found necessary to run water constantly over the rolls and roll necks for the dual purpose of cooling and blowing off scale which may be formed as the ingots, bars or billets are broken down.

Some mills, in addition, blow steam directly onto the ingot during its first pass through the rolls in order to more effectively remove the scale. Such conditions coupled with the extreme heat which is constantly encountered places a most exacting requirement upon the roll neck and gear lubricants. These must, therefore, be compounded products, inasmuch as straight mineral lubricants cannot withstand the continued washing action of hot water.

The usual procedure is to compound gear and pinion lubricants with definite percentages of certain substances which will give the final product the desired adhesive properties. Any rolling mill gearing, however, which does not come in contact with water can readily be served by a straight mineral gear lubricant of a viscosity ranging from 2000 to 5000 seconds Saybolt according to temperature conditions and the manner of lubrication.

Blooming Mill Pinions

The pinions adjacent to the roll necks in the blooming mill are usually enclosed in an oil-tight casing in which event they are run in a bath of specially prepared gear lubricant of high adhesive characteristics and considerable body.

In some installations, however, these pinions may be only covered with shields which are not oil tight. Where this is done there is often no bottom to the gear case; therefore, bath lubrication is out of the question. Hence the lubricant must be able to stick tenaciously to the pinions over the periods which intervene between its application, and maintain a sufficiently protective film. A viscosity of about 5000 seconds Saybolt at 210 degrees Fahr., has been found to be necessary in order that the resultant lubricating film will be able to withstand the terrific pounding and hammering which occurs, especially when the mill is reversed.

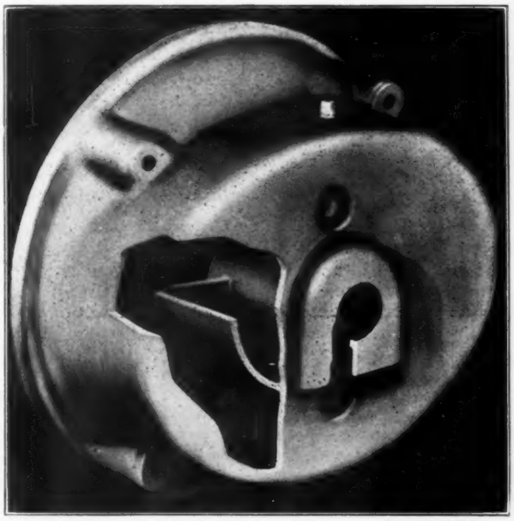
Continuous Mills

The rolls of continuous mills in turn are usually driven by herringbone pinions, and a set of relatively heavy gears. These pinions in such a mill are often so constructed as to make it necessary to lubricate the bearings with grease under a continuous flow of cooling water.

Naturally this water will splash onto the exposed parts, involving a condition and requiring a grade of lubricant as has been mentioned above in discussing the blooming mill. Certain mills, however, may be built with oil-tight gear cases and suitable shields which will permit of bath lubrication. This, of course, affords more complete protection of both the lubricant and gear teeth.

Table Rollers

The bevel gears which drive the table rollers nearest to any type of rolling mill, frequently operate exposed. They are, therefore, subject to water conditions, flying scale and the heat which radiates from the hot metal in its course through the plant. Here the gear lubricant is difficult to apply, in the first place, and furthermore, after it has been applied, operating conditions may prevent its functioning effectively. Centrifugal force may be especially harmful as it will tend to cause the lubricant



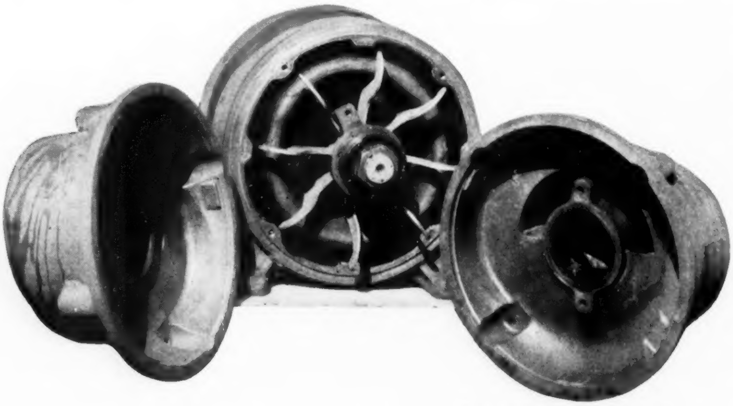
Courtesy of The Louis Allis Co.

Fig. 7 Cut-away of the Louis Allis splash-proof motor showing water trap and drain. Note there is no straight line for water to enter the motor, due to design of baffles, shaft guard and traps.

to throw off, especially where the latter has suffered any extensive reduction in viscosity, due to overheating.

The washing action of the water which splashes over such gears is also a detriment.

In addition, excessive contamination by solid foreign matter can hardly be avoided, unless precaution is taken to effectively guard such gears. Ultimate protection can only be attained, therefore, by frequent applications of a lubricant which has such properties as to withstand these detrimental conditions.



Courtesy of The Louis Allis Co.
Fig. 8—Showing interior design of the same type of motor, after a severe test run exposed to a stream of water. All parts were found to be perfectly dry.

Usually the same type of product as recommended for the blooming mill gears must be used, having a viscosity of from 1000 to 2000 seconds Saybolt at 210 degrees Fahr., according to weather and temperature conditions involved. It should be applied by pouring onto the teeth at the point of mesh while the gears are running inward.

Plate Mills

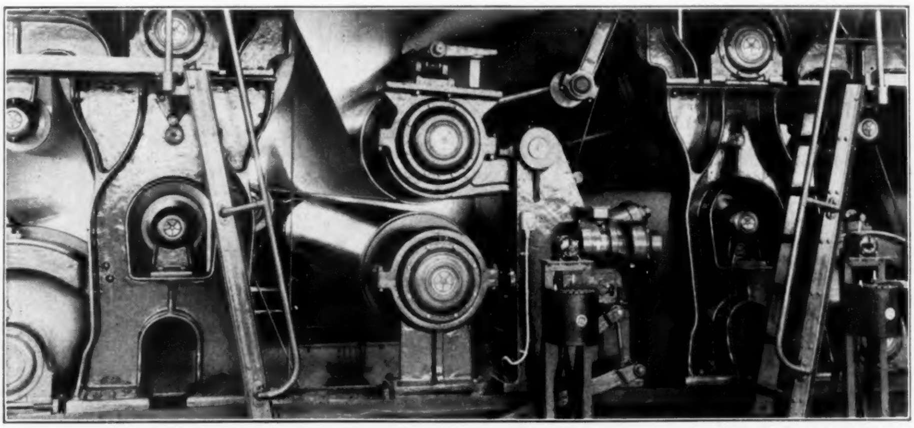
Plate mills involve an additional detriment due to the quantities of salt which are thrown on the plates to remove scale during the process of rolling, and also the fact that the red hot plates pass directly over the bearings and gears of the table rollers.

Water may also be sprayed on the rolls. These factors, coupled with flying scale and dust which is driven with considerable force when the hot gases explode, tend to destroy any lubricant used on the roll necks, table roller bearings and gears. Gear compounds as specified above, however, have been found to withstand these detrimental elements quite satisfactorily provided they are applied at frequent intervals and in sufficient quantities.

Here an additional property which the gear lubricant must possess is an ability to resist being thinned out by the oil which is used on the pinion bearings, inasmuch as a good deal of this latter will often work out and onto the gear teeth.

Pumping Machinery

In deep well pumping operations water is usually brought to the surface through a pipe within which the pump shaft is located. This shaft carries one or more impellers, according to the depth involved, the amount of water to be pumped, and the size of the well casing. It is the function of these impellers to raise the water at the requisite rate of discharge. Rotation is usually brought about by means of electric motor power.



Courtesy of S.K.F. Industries, Inc.
Fig. 9—An assembly of anti-friction bearings on a modern Pusey and Jones paper machine. Note compact nature of housings. Moisture conditions in some stages of the paper industry may be very severe, hence the care with which the modern bearing is housed to afford maximum protection.

One of the essential lubricating problems on such pumps is to take care of the steady bearings in the cover pipe. These serve to center and hold the shaft in proper alignment, prevent deflection and maintain the requisite pressures with as vibrationless operation as possible. But only can these ideals be attained through the medium of effective lubrication. Essentially, the lubricant should be so constituted that it will

(1) maintain the requisite lubricating film;
(2) have as little tendency as possible to run out at the bottom of the pump from between the shaft and casing or cover pipe; and
(3) show but little internal friction, otherwise this would act as a brake on the impeller shaft.

Water can, of course, be used as a lubricant on such pumps, especially where a cover pipe is not employed. It is effective, economical, and prevents the possibility of contamination of the water being pumped, especially when used on rubber or hard wood bearings.

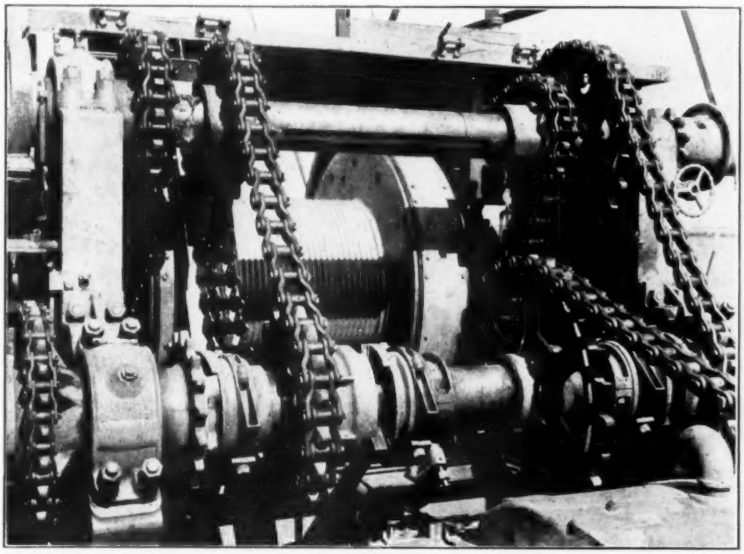
Under certain conditions of sand, or the presence of other such fine particles of foreign matter in suspension, it is, however, generally considered better practice to provide for oil lubrication, installing a suitable cover pipe and bearings of design capable of bringing this about.

Bearing Design a Factor

Whatever the type of lubricant, however, the design and location of the bearings is a most important feature. Usually they must be set relatively close together. On certain pumps this distance is approximately eight feet

Where lubrication by means of fluid oil is practicable, due to the high speeds involved, it will usually be best to use a comparatively low viscosity product. In general, a viscosity of from 180 to 200 seconds Saybolt at 100 degrees Fahr., will serve the purpose, providing that the stuffing box in the bottom of the cover pipe gives the requisite seal.

Under conditions of a marked difference in head, however (especially where automatic circulation of the oil is not provided for), the oil might exert a pressure on the openings around the bottom bearings so much greater than would the water in the well (particularly when the pump is not operating) that this oil would run out at the bottom between the shaft and cover pipe, if the stuffing box happened to be worn to any extent.



Courtesy of Link Belt Co.

Fig. 10 A typical draw works in oil field service showing the extent to which special chains are used. The protection of these elements, to prevent rust and corrosion is a most important item in oil rig maintenance.

This would be indicated by an excessive consumption of oil. The procedure in such a case would be to resort to a grade of light grease which will not only be capable of giving adequate lubrication with as low a drag as possible, but also will have sufficient body to resist the unbalanced pressure which may be involved.

As wear on the stuffing box increases, it may in turn be necessary to use a heavier grade of grease, though, of course, this may involve the sacrifice of a certain amount of mechanical efficiency. Such a grease should have a consistency very nearly the same as that of vaseline, and should be a product which will retain its plasticity at the approximate temperatures of pumping.

Where the shaft and steady bearings are located in a pipe, the adaptation of automatic balanced circulation lubrication, whereby oil is fed from a surface tank so located that oil and water pressures will be equalized, is claimed to eliminate the possibility of waste and contamination of the well water. This oil is pumped through the bearings and back via a return pipe, by a suitable lubricant pump. Such a system makes possible the continued usage of a fluid lubricant capable of giving the desired results with the least development of internal friction.

Mine Pumps

Another type of pump, the operation of which may often involve lubricating problems is the mine pump so necessary in the anthracite coal fields, etc. Here water conditions may be very bad; therefore, it is necessary to employ the most rugged type of heavy duty pump to keep the sumps and galleries clear. For this purpose, naturally, many makes of pumps are used. In general, however, they will involve either the horizontal reciprocating steam or air-driven pump, the vertical motor-driven triplex pump or the centrifugal pump.

Bearings of Centrifugal Pumps

Where bearings alone are involved as in the motor-driven centrifugal pump, lubrication will be a relatively simple matter. Ring oilers predominate and these can usually be taken care of by means of a medium body straight mineral engine oil of from 200 to 400 seconds Saybolt viscosity at 100 degrees Fahr. This same oil can also be used with satisfaction on the external bearings of reciprocating pumps.

In lieu of oil, however, certain builders will prefer grease due to the fact that frequently there will be less chance for dust or dirt gaining entry to score or abrade the bearings. With either the compression or spring type of grease cup, a medium bodied cup grease will serve the desired purpose. It is furthermore of advantage wherever shaft ends are exposed, for a seal of grease will prevent the entry of dirt more readily than an oil film due to its higher consistency, and the degree to which it "stays put" in the bearing.

Plunger Lubrication

Where mine pumps are of the outside packed plunger type they require a lubricant which will keep the packing properly sealed and prevent excessive wear on the plungers.

A relatively high viscosity straight mineral lubricant will usually serve this purpose. Not only will such a product lubricate the plunger, but also it will seal the clearance space effectively and lubricate the packing so that there will be little or no danger of this being damaged. Another advantage of such a lubricant is that it will adequately protect the plunger from the corrosive effects of sulphurous compounds with which the mine water may be contaminated.

Hydraulic Equipment

The hydraulic elevator and the hydraulic accumulator are examples of the use of water power for the conservation and transformation of energy. The earlier types of elevators employed in building construction were frequently of the hydraulic type. More recently the same principles have been employed in the construction of certain types of sidewalk hoists.

The hydraulic accumulator, as it is termed in the steel industry, serves more or less the same purpose as a fly-wheel, in that it is used to accumulate energy for subsequent usage in operating the doors of the soaking pits or for certain types of shears.

The mechanism of the accumulator involves a suitable storage tank capable of retaining water under the pressure involved. By means of control valves, the power contained therein can be made to act upon a heavily weighted plunger, via its retaining cylinder.

Media Employed

While the term "hydraulic" implies the use of water, it has been developed that light oils can also be employed with excellent results as, for example, in the case of the marine telemotor and in the operation of certain types of hydraulic presses and power transmission devices.

The extent to which lubrication is involved is confined to the plungers and piston rods. The purpose is to maintain the leather cups of the control valves in a soft, pliable condition and prevent too rapid deterioration of the packing. In a closed system this may be accomplished by adding an emulsifying compound to the water. By use of a compound, such as soluble oil, precipitation of any fine grit or impurities which may be held in suspension is also brought about, to thus prevent possibility of excessive wear on the moving parts with which water must come in contact. An effective method of lubricating plungers, especially in the steel industry, to prevent scoring, preserve the packing and reduce water leakage, involves the use of sight feed oil cups.

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